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**SEISMIC METHODS IN
MINERAL EXPLORATION:
HEATH STEELE MINES,
NEW BRUNSWICK**

Larry Petrie and Gary Woods
Noranda Inc.

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Seismic Methods in Mineral Exploration:
Heath Steele Mines, New Brunswick

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Prepared for:

Minerals, Policy and Planning Division
Department of Natural Resources
Province of New Brunswick

Hon. Donald Arsenault
Minister of Natural Resources

March 2007

Natural Resources
Minerals, Policy and Planning

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MINERAL EXPLORATION:
HEATH STEELE MINES,
NEW BRUNSWICK

Larry Petrie and Gary Woods
Noranda Inc.
Bathurst, New Brunswick

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HEATH STEELE MINES, N.B.**

Prepared by:

Larry Petrie and Gary Woods

**Noranda Inc.
Atlantic Canada Region
P.O. Box 30, 920 Bridge Street
Bathurst, N.B.
E2A 3Z1**

March 1999



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Abstract

A 2D "side-swipe" seismic survey was completed along a 6.3 km traverse in the Heath Steele area, New Brunswick. The traverse was located north and parallel to the main Heath Steele horizon that consists of ore grade deposits with contained sulfide contents of between 80 to 100 mT. Forward modeling on computer constructed geological models, simulating the Heath Steele geological environment, suggested a 2D seismic survey should produce weak scattered energy from the isolated sulfide sources. The survey was designed to evaluate the effectiveness of using seismic techniques to determine if off-line diffracted energy from known sources could be detected along near vertically dipping stratigraphy.

Initial processing of the seismic data indicates significant reflectivity throughout the entire stack. No significant coherent energy is observed within the first 400 milliseconds (~1200 meters). Amplitudes appear to increase in the vicinity of expected reflectivity; however, no discrete high amplitude reflectors or diffractors appear to be associated with the known sulfide accumulations.

Acknowledgements

Noranda Mining and Exploration Inc. is grateful to Steve McCutcheon, Department of Natural Resources and Energy, Bathurst for ongoing interest in the project. This work was supported by the 1998 Value Added / Mineral Processing Program (VAMP), New Brunswick Department of Natural Resources and Energy.



1.0 INTRODUCTION

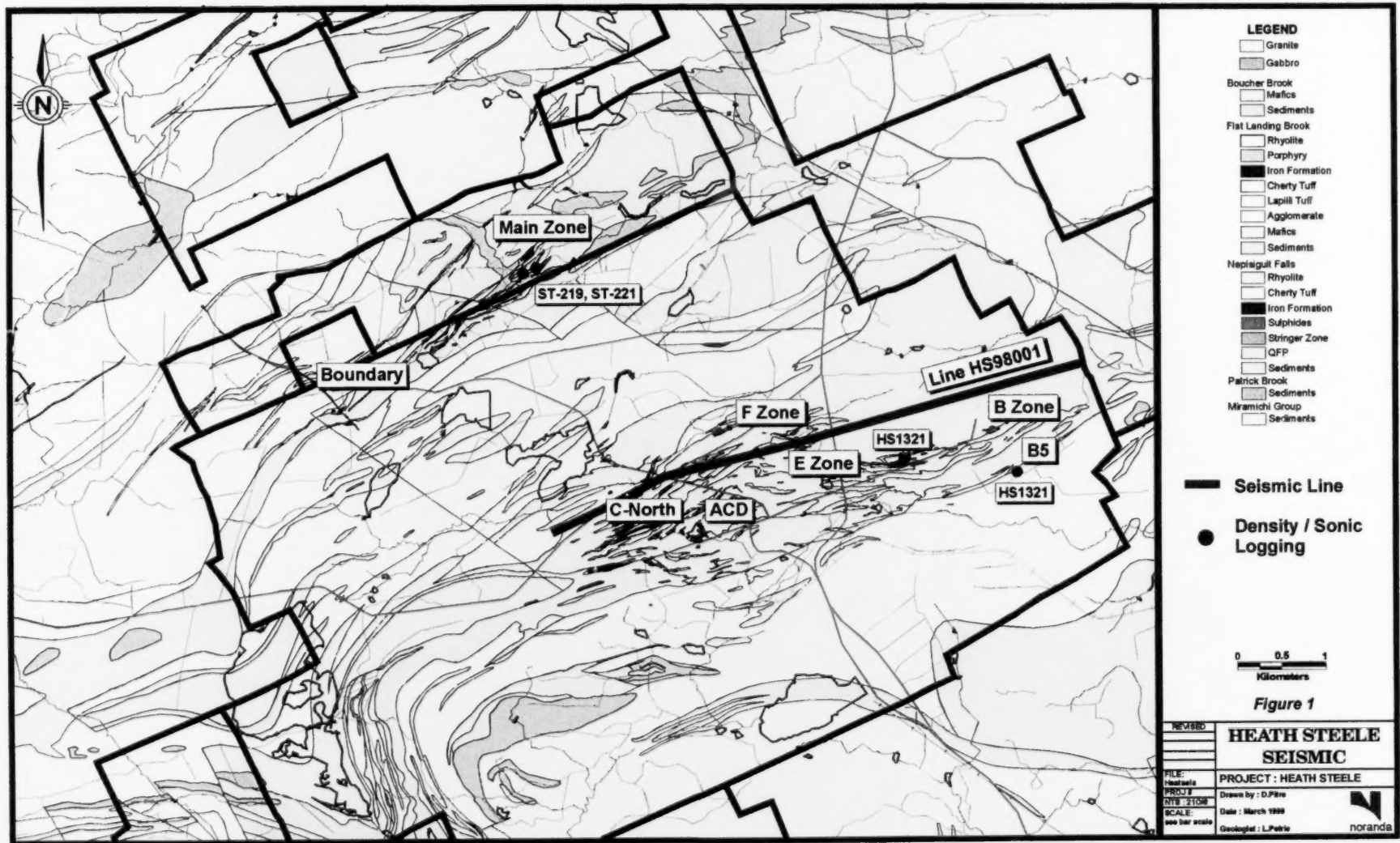
1.1. Objectives

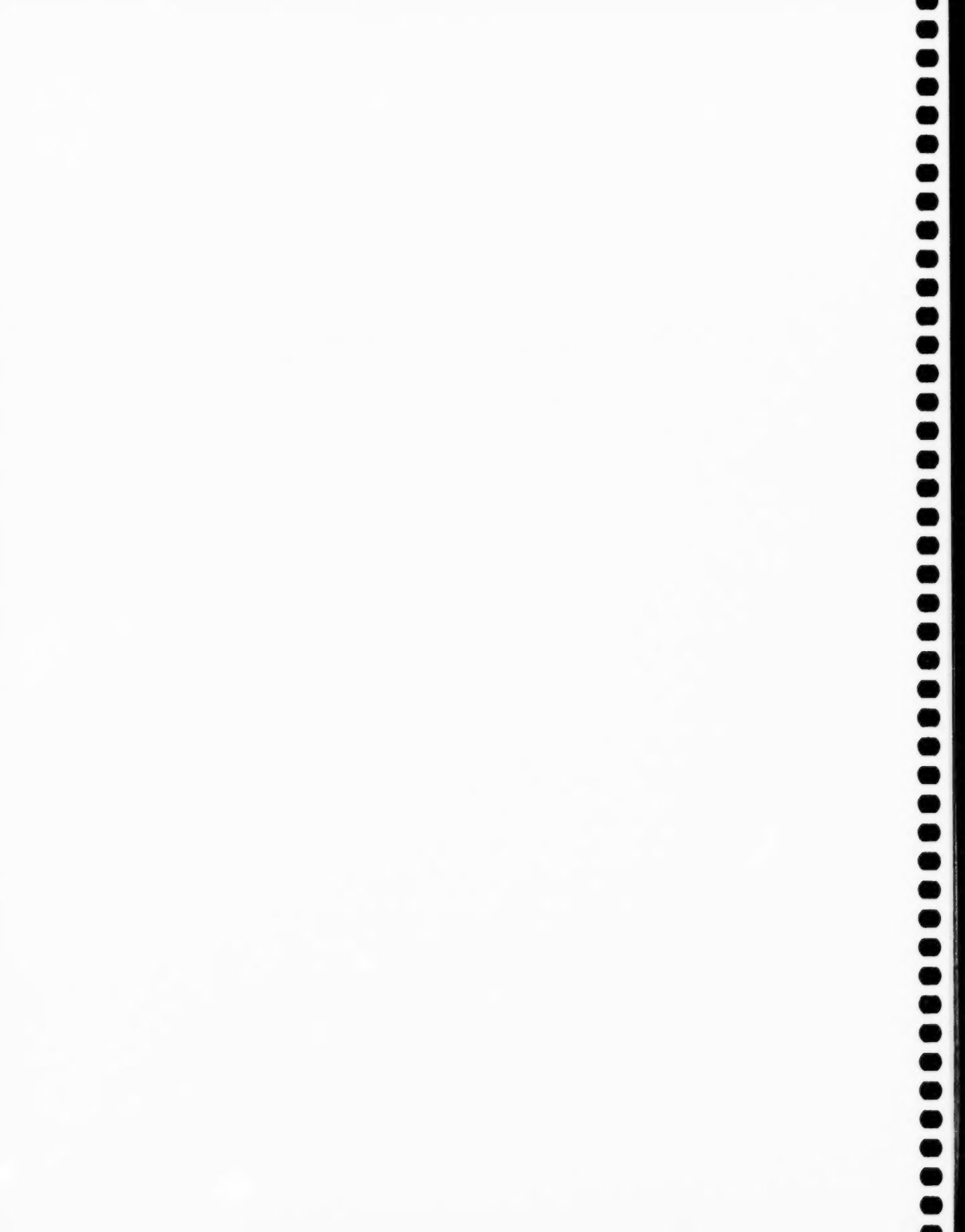
The Heath Steele seismic experiment is designed to examine the feasibility of using 2D "side-swipe" techniques as an effective exploration tool. The survey will examine the nature of scattered energy along a near vertically dipping, prospective horizon that includes the remaining sulfides within the B-Zone deposit and approximately 5 km of prospective stratigraphy along the main Heath horizon (Figure 1).

1.2. Scope

Conventional geophysical techniques provide adequate means to identify near surface targets. These methods, in effect, limit exploration programs to within a few hundred meters of surface. Seismic techniques are capable of examining prospective stratigraphy well beyond the limits of conventional methods yet the acquisition and detection capabilities have yet to be proven.

The Heath Steele experiment could potentially allow a large stratigraphic package to be evaluated more cost effectively by positioning a 2D survey parallel to a prospective horizon rather than using multiple dip lines. Physical property measurements and forward modeling on computer constructed geological models simulating the geometry of a folded sulfide body, suggest that this method may provide an effective search tool provided adequate S/N (signal/noise ratio) could be achieved in the data.





1.3. Background

Previous seismic studies by Noranda Mining and Exploration Inc. indicate that high frequency reflection techniques return sufficient energy to delineate source targets. Most of these studies have focused on areas in relatively flat lying geological environments. In the Bathurst Camp, most of the areas of known mineralization are located on steeply dipping or near vertical stratigraphy. The effective use of surface seismic techniques in these environments is poorly understood. The Heath Steele area provides an opportunity to evaluate the use of seismic methods in a geologically challenging environment.

To evaluate the usefulness of seismic methods several background studies were required prior to the acquisition of data. Rock property measurements on select geological units, within the Bathurst Mining camp, were required to determine the reflective nature of the host lithologies and their relationship to sulfide bodies. The measurements indicate seismic methods are particularly suited to discriminating massive sulfides from the surrounding rocks (Figure 2). Acoustic impedance calculations from velocity and density measurements on rocks from within the Heath Steele area show that most sulfides have significantly higher acoustic impedance than the host lithologies. In fact, while measurements predict that the sulfide bodies should produce strong reflections/diffractions, the host lithologies that make up the surrounding stratigraphy in the Heath Steele area show no significant variations in impedance contrasts and should be relatively transparent. These measurements imply that high-resolution seismic methods may be useful for the direct detection of massive sulfide accumulations as discrete targets.

In order to test the feasibility of the "side-swipe" technique, computer generated models were constructed to represent an undulating massive sulfide body with characteristics similar to the sulfide horizon at Heath Steele. These

Physical rock property measurements.

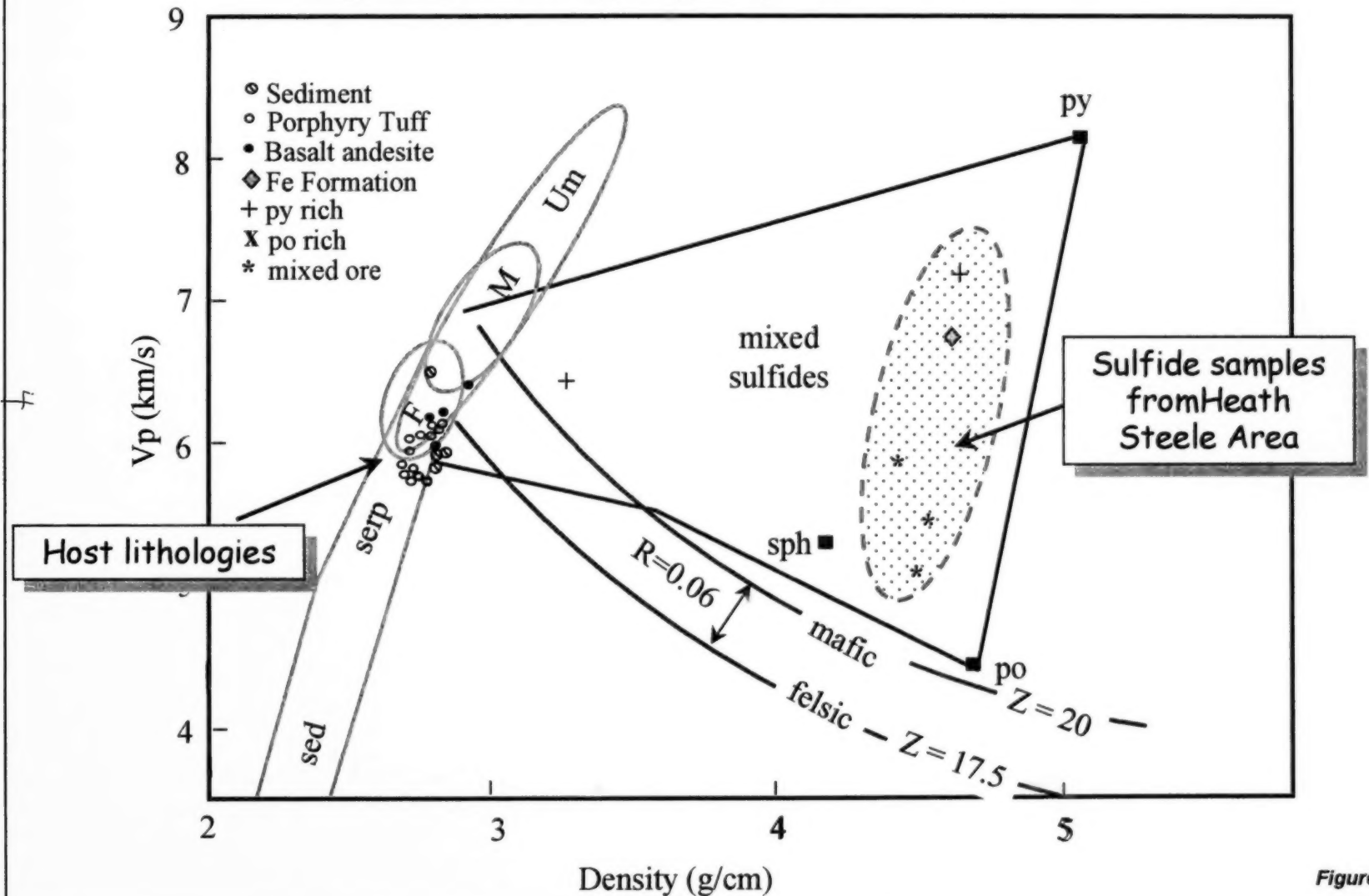


Figure 2

models were assigned physical characteristics representing those measurements described from the rock property studies. The weak scattering response was then calculated numerically using a Born approximation and synthetic seismic profiles were generated along a profile representative of an actual survey. The results of this forward modeling suggested sufficient scattered energy should result from massive sulfide concentrations similar to the environment at Heath Steele (Figure 3).

2.0 PROJECT METHODOLOGY

2.1 Survey Planning and Preparation

In preparation for the seismic survey, a 6.3 km (by 4 meter wide) line roughly orientated E/W was cut to provide access for the survey. Following cutting, the line was surveyed for positioning with shot and receiver stations established at specified intervals along the line. At each recording station a small patch was established by removing a small quantity of vegetated cover to allow for optimal geophone coupling. At each shot location, a 6 meter deep hole was drilled with a track mounted combined auger/percussion drill and loaded with explosive sources. A total of 227 holes were drilled during the early September 1998 two weeks prior to recording the survey. To ensure safety precautions, a 24-hour guard routine was established with both the Heath Steele mine and independent personnel to patrol the survey site. The recording of the program was planned in conjunction with a survey in the Halfmile Lake area.

2.2 Layout and Recording

A total of 6.3 km of seismic profiling was completed along a single line between September 22-24, 1998. Western Geophysical Inc., Calgary, performed seismic acquisition. Supervision of the survey was conducted by

2D side-swipe response from a modeled sulphide body

The diffraction from the lower deposit is indicated by the arrow. The S/N is 5:1 and the line offset ~ 500 meters.

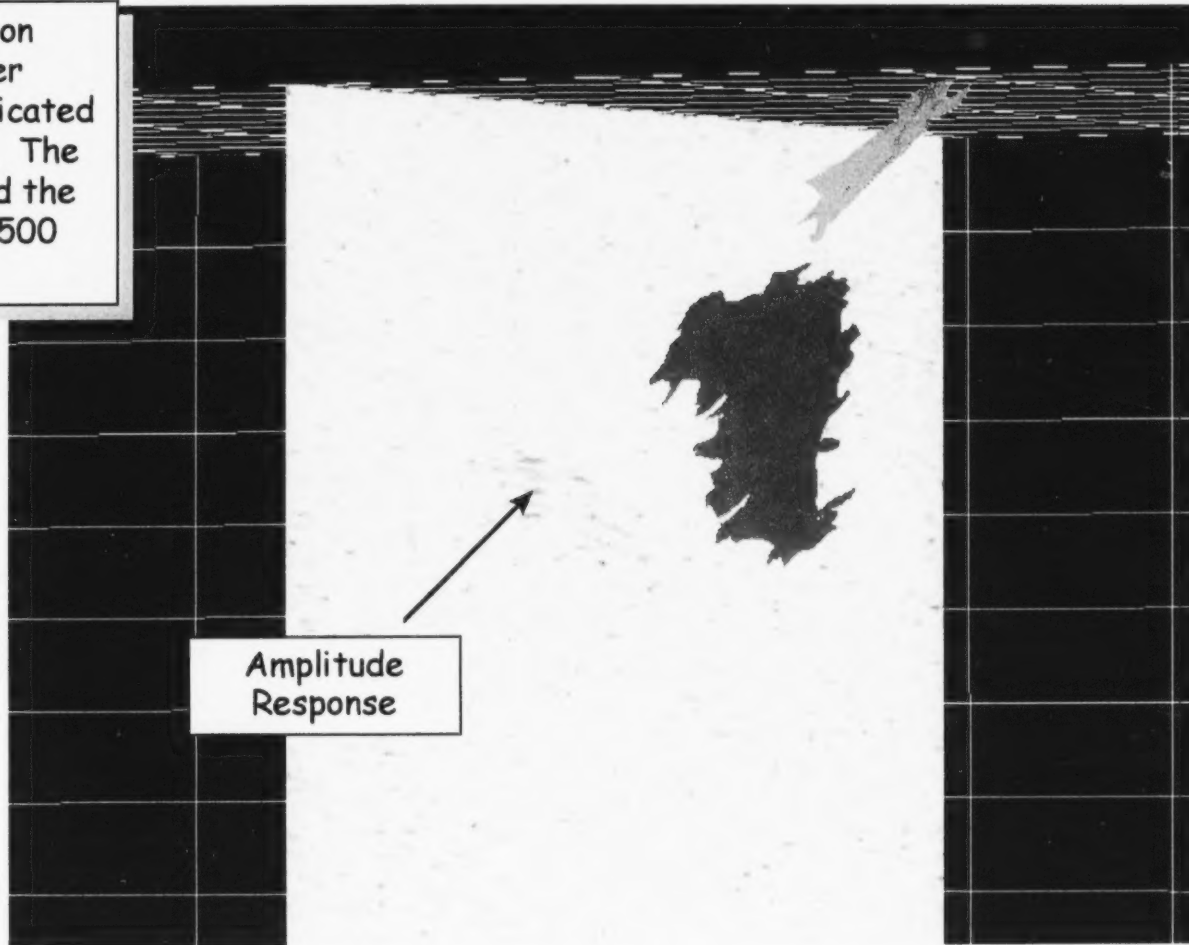


Figure 3

Lloyd Whelan, Western Geophysical and overseen by L. Petrie and L. Matthews, Noranda Mining and Exploration Inc. A summary of the acquisition parameters used for the survey follows:

Table 1 - Survey Parameters:

Line length	:	6.32 km
RX interval	:	10 meters
SP Interval	:	40 meters (20 meters on East End)
Total SP	:	227
Charge size	:	500 gm. Dynoseis
Sampling Rate	:	2 ms for 3 seconds

2.3 Processing

Processing of the data was conducted during October & November 1998 by EI Processing Inc. of Calgary. The processing flow focused mainly on 1) the reduction of source generated and ambient or background noise; 2) the application of reliable weathering static corrections; 3) the determination of the best stacking velocity and 4) the final migration imaging. The basic processing sequence is shown in Table 2.

Table 2 - Processing Sequence

1. Demultiplex
2. Geometry
3. Trace Edits
4. Gain Correction
Type: Exponential
5. Relative Amplitude Scaling

6. Multi-Component Deconvolution

Type:	Trace to trace
Output phase:	Zero
Design Gate:	0.1 –2.5 sec. at 10m 1.5 –2.8 sec at 3400m
Frequencies:	4/10 – 100/120
7. Trace Balance
8. Elevation & Weathering Statics

Refraction Statics:	2 layer
Weathering Velocity:	900 m/sec.
Replacement Velocity:	5350 m/sec.
Datum Elevation:	400 m (a.s.l)
9. Residual Statics

Window:	0.40 – 1.20 sec. 0.50 – 1.40 sec.
Maximum static:	+/- 20 msec.
Iterations:	4
10. Velocity Analysis

Type:	Coherency Spectra
-------	-------------------
11. Normal Moveout Correction
12. First Break Mute
13. Residual Normal Moveout Correction
14. Time Domain Noise Attenuation
15. Spatial Domain Noise Attenuation
16. Pre-stack Time Migration
17. Stack
18. Final Filter: 18/24 – 75/90
19. Relative Amplitude Scaling

The processing flow started with demultiplexing from field format SEG-D into standard SEG-Y. Field geometry was added to the trace headers and selective shot and trace edit step followed. Data was discarded on the basis of S/N and overall energy level. The data was then corrected for spherical divergence amplitude loss and a two-pass deconvolution applied. This successfully compressed the wavelet and whitened the amplitude spectrum. A high white noise level was used because of the relatively low S/N of the data. The strong first break energy recorded over the entire spread on most shot records, allowed for a very reliable 2 layer near surface velocity model to be calculated. This was done using Green Mountain refraction static software.

Elevation and weathering static corrections were applied based on this model. The final seismic reference datum was 400 m ASL. Detailed velocity analysis was conducted every 100 CDP's (common depth points) or 500 meters along the entire line. A coherence spectra analysis methodology was used. Again, the low S/N made this task difficult; however, apriori knowledge of the rock lithologies in the area, allowed a reliable and laterally consistent NMO (normal moveout) function to be applied. After first break mutes, residual NMO and statics were applied, two types of noise attenuation schemes were employed. Each was designed to specifically deal with random and coherent noise trains. Random noise was attacked in the time domain; however, the largest random noise reduction would be accomplished with the stacking process as over 200 fold was achieved in the middle of the line. The coherent noise was more problematical. This was not only low velocity, near surface; shot generated noise but also underground mine generated noise. These noise trains were attacked in the time – space domain with a multi-channel process. The noise reduction needed was not achieved in the upper 1 second of the data and this is apparent on the structure stack as low frequency, patchy reflectivity. Migration imaging was accomplished with a DMO (dip moveout) partial prestack migration in order to try and deal with conflicting dips having different stacking velocities. The final imaging step used a residual, prestack time migration approach. A final filter and relative amplitude scaling produced the structure and migrated stack sections (Appendix A).

3.0 RESULTS AND DISCUSSION

Overall, the data quality gathered during this survey was clearly the best S/N achieved to date. In comparison to a 1996 survey along the same traverse, deep return energy was substantially improved by sources drilled and loaded within the bedrock. Better geophone coupling was also achieved. Individual shot records indicate that first break energy from most sources was acquired along

the entire length of the spread. Select shot records show strong amplitude emanating from point sources within the existing mine infrastructure. Ambient noise levels from wind and weather conditions were generally acceptable; however, background noise generated from the mining activities was generally high. This noise was expected to effect the processed dataset.

Return energy from within the first 300-400 ms is generally too low and noise contaminated to provide any qualitative interpretation. Below this time, information that can be obtained from the dataset is limited. Evidence of a high amplitude reflection occurs at depth (SP 101-550, 1.4-2.1 ms). This is indicative of the higher quality and better signal penetration of this 1998 line when compared to the 1996 data. The nature of these reflective events is unknown although it can be hypothesized that the extrapolation of these events may indicate deep lying regional structures that are pervasive throughout the camp.

Several amplitude anomalies are present within the first second of the seismic section. Some of the higher amplitude events can be roughly correlated with known zones of mineralization along the line, but the nature of the return energy is generally not coherent to qualitatively discriminate isolated sources. No discrete amplitude anomaly is associated with the known mineralization within the B-Zone. Increased energy returns within the first second could greatly improve the ability to image known sources along this horizon. It is postulated that this improved S/N could be achieved by increasing the distance between the sulfide horizon and the receiver locations. A more complete study of this design is warranted.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Several economic deposits within the Bathurst Camp are located on near vertical or steeply dipping stratigraphic horizons. The ability to use 2D seismic "side-swipe" techniques along known horizons may provide a cost effective exploration tool to successfully evaluate prospective stratigraphy. The

successful use of these techniques could greatly alter our approach to exploration programs.

Although no discrete amplitude events were observed with zones of known mineralization, increased amplitudes near these zones maybe indicative of weak energy returns. Ambient noise levels may be too high to distinguish scattered responses from background noise. How best to deal with the coherent noise originating from underground in the mine, remains a particularly large problem. This will be an issue wherever we are looking for weak scattering energy in a noisy mine environment. Further processing on the dataset will be preformed to determine if the reflectivity observed in the profiles can be enhanced in the areas of interest. Future work may provide suitable targets for further exploration activities in this area or along other horizons within similar geological settings.

5.0 REFERENCES

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- Salisbury, M. H., Milkereit, B., Bleeker, W., 1996. Seismic imaging of massive sulphide deposits. 1. Rock properties. Econ. Geol. 91, 821-828.
- Zaleski, E., Eaton, D. W., Milkereit, B., Roberts, B., Salisbury, M., Petrie, L., 1997. Off-line seismic reflections from subvertical diabase dykes in an Archean terrane; implications for the interpretation of subhorizontal reflections. Geology 25, 707-710.

APPENDIX A

Noise attenuated structure stack

Noise attenuated migrated stack

APPENDIX B

Statement of Expenditures

NORANDA MINING AND EXPLORATION CO. LTD.
HEATH STEFLE 2D PROGRAM
SN 388 632 CHANNEL TELEMETRY CREW
SINGLE HOLE - 0.5KGS @ 9 METERS - 40 METER SHOTPOINT INTERVAL

Total Square Kilometers: 1.000
 Total Square Miles: _____
 Total Shotpoints: 180
 Total Receiver Points: 633

DATE: Feb 28, 1999

KMS of Receiver: 6.32 kms
 KMS of Source: 6.32 kms

ESTIMATED PREPARATION COSTS				ESTIMATED TOTAL COST	COST/SP	Actual Total Cost	Invoice #
1	Pre-Scout/Helicopter/Approvals/etc.						
2	Advance Party Manager	30 days @ \$600/day					
3	Advance Clerk	10 days @ \$300/day					
4	Line Push(s)	0 days @ 700/day					
5	Medic/Ambulance	0 days @ \$450/day					
6	Slashing - New Cut	6.32 km's @ \$1500 km		\$ 10,000.00	\$ 55.56	\$ 9,050.00	
7	Retrieve & Transport			\$ 2,500.00	\$ 13.89		
8	Receiver Station Prep			\$ 3,000.00	\$ 16.67		
9							
10	Survey/Chaining	6.32 km's @ \$500 km		\$ 3,160.00	\$ 17.56	\$ 2,250.00	
11	Drilling - Track Hammer	3 days @ \$8400 day		\$ 25,200.00	\$ 140.00	\$ 16,800.00	
12	Drill Push	3 days @ \$575 day		\$ 1,725.00	\$ 9.58	\$ 1,725.00	
13	Drilling - Consumables	3 days @ \$695 day		\$ 1,785.00	\$ 9.92		
14	Drilling - Mod/Demob	4 trips @ \$400 per trip					
15	Explosives & Expendables	180 SP's @ \$23 per SP		\$ 4,140.00	\$ 23.00	\$ 6,371.00	
16							
17	Inter Survey Trucking	Fixed Rate		\$ 5,000.00	\$ 27.78		
18	Night Watchman	7 days @ \$250 day		\$ 1,750.00	\$ 9.72	\$ 1,000.00	
19	Processing	180 Records @ \$20 Record		\$ 3,600.00	\$ 20.00	\$ 3,405.00	
20							
21							
22							
23							
24							
25							
26							
SUBTOTAL:				\$ 61,860.00	\$ 343.68	\$ 40,601.00	

ESTIMATED RECORDING COSTS							
27	Recording - Mob/Demob	Flat Rate				\$ 25,500.00	
28	Recording - Heliportable	2.5 days @ \$12360/day		\$ 30,900.00	\$ 171.67	\$ 30,502.00	
29	Helicopter	6 hrs. @ \$1250 Hr.		\$ 7,500.00	\$ 41.67	\$ 6,900.00	
30	Helicopter Mob/Demob	5 Hrs. @ \$1250 Hr.					
31							
32							
33	Convert Geophones						
Subtotal:				\$ 38,400.00	\$ 213.34	\$ 62,902.00	
TOTAL ESTIMATED/Actual COST:				\$ 100,260.00	\$ 557.02	\$ 103,503.00	

Actual COST PER KM: \$ 16,377.06

Actual 1



11 WEST LANE - BATHURST, N.B. E2A 4Z2
Tel./Fax (506) 546-6770 e-mail:norm@nbnet.nb.ca

September 11, 1998

Health Steele
Project #HST 98-001
Invoice # 13056

Mr. Larry Petrie
Noranda Mining & Exploration Inc.
P.O. Box 30,
Bathurst, NB
E2A 3Z1

copy.

INVOICE

2 days for 1 man with Porter @ \$160./day	\$ 320.00
6.0 kilometer of 3 meter lines including detours @ \$1125./km.	<u>6750.00</u>
Subtotal	\$7070.00
HST (15%)	<u>1060.50</u>
Total	\$8130.50

Frances Ranthier



MIDDLE RIVER WOOD CONTRACTORS INC.

11 WEST LANE, BATHURST N.B.

E2A 4Z2

(506) 546-9621

email: norm@nbnet.nb.ca

September 11, 1998

Health Steele
Project # HST 98-011
Invoice # 13468

Mr. Larry Petrie
Noranda Mining & Exploration Inc.
P.O. Box 30,
Bathurst, NB
E2A 3Z1

copy

INVOICE From September 8th to September 9, 98

12 hours with porter @ \$45./hr.

\$ 540.00

4 hours floating Heath Steele to Bathurst @ \$65./hr.

260.00

Subtotal

\$ 800.00

HST (15%)

120.00

Total

\$ 920.00



EAGLE SURVEYS LTD.

#106. 1915 - 27 Avenue N.E., Calgary, Alberta T2E 7E4
Telephone: (403) 250-5100 • Fax: (403) 250-9163

Invoice No. : 98-163
Job No. : 98-N4-4728
Crew No. : 04
GST No. : R101538288
Date : September 15, 1998

Noranda Mining and Exploration Inc,
#2800 605 5th Avenue S.W.,
Calgary, Alberta
T2P 3H5

Attention: Mr. Larry Matthews

RE: Prospect - Heath Steele

To provide a surveyor for the above prospect for the following days.:

Francois Routhier:

September 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14, 1998

10 days at \$ 700.00 per day

\$ 7,000.00

GST at 7%

\$ 490.00

TOTAL AMOUNT OF THIS INVOICE

\$ 7,490.00

copy

OK LMF
Charge to 119-065 SEISMIC.
199-065 - to be deducted from estimate
J.P.
Oct 1 '98

BERTRAM DRILLING CORP.

BOX 3007 AIRDRIE ALBERTA T4B 2B4
403-263-8563 403-572-3591

NORANDA MINING EXPLORATION
C/O WESTERN GEOPHYSICAL
2720 - 5 AVE NE
CALGARY AB
T2A 4V4

INVOICE DATE: Sept. 30, 1998
INVOICE # 4605
DEPT. : 12 NB
TERMS: 30 days

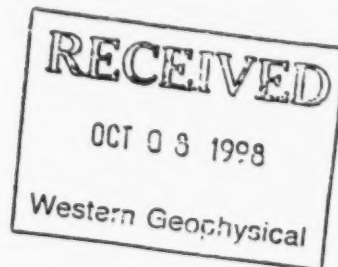
Description		Rate	Amount
RE: HEATH STEEL			
UNIT #417			
Drilled	25 hours	\$175.00 per hour	\$4,375.00
Mud	4 litres	\$9.00 per litre	\$36.00
UNIT #418			
Drilled	32 hours	\$175.00 per hour	\$5,600.00
UNIT #420			
Drilled	32 hours	\$175.00 per hour	\$5,600.00
DRILL PUSH - BEN WURZ	2 days	\$575.00 per day	\$1,150.00

copy only
PAM Oct 14 '98
OK Lm
change to 199-065

SUBTOTAL \$16,761.00
7% G.S.T. \$1,173.27
TOTAL BILL \$17,934.27

BERTRAM DRILLING CORP.

B. Buttrick
(for)
Brian Bertram
Manager



G.S.T. #R136229366

EAST COAST EXPLOSIVES LTD.

P.O. Box 1241
Fredericton, N.B. E3B 5C8
Tel: (506) 459-1875
Fax: (506) 450-7444

Explosives * Seismographs * Accessories

INVOICE

NO. 4865

DATE 9/30/98

PAGE 1 of 1

SOLD TO

NORANDA MINING AND EXPLORATION INC.
ATTN: MR. LARRY PITRE
P. O. BOX 30
BATHURST, E2A 3Z1

SHIP TO

NORANDA MINING AND EXPLORATION INC.
BLASTER AND EXPLOSIVES CHARGES
1/2 MILE LAKE
AUG 29/98 - SEP 23/98

Business No.: 13866 2202

TERMS: NET 30 DAYS, INTEREST AT 2% PER MONTH
(26.8% PER ANNUM) CHARGED ON OVERDUE ACCOUNTS

ITEM NO.	QUANTITY	UNIT	DESCRIPTION	GST PST	UNIT PRICE	AMOUNT
19990	899	Each	Dynoseals 0.5 kg	3	11.00	9,889.00
19993	700	Each	10.6M Electric Super Seismic	3	9.75	6,825.00
19994	5	Case	Plugs - Spider	3	215.00	1,075.00
19995	5	Case	Points - Drive 50mm	3	105.00	525.00
	238	Hour	Blaster	3	45.00	12,960.00
			3 - HST @ 15.0%			4,691.10
			Terms: Net 30. Due 10/30/98.			
Invoice for 100 yd³ to come # 4910 OK Lm Charge to 199-065 Seismic						
TOTAL →						35,965.10

277

EIPROCESSING INC.

Client: NORANDA INC.
Address: 2800, 605 - 5 Avenue SW
Calgary, AB
T2P 3H5

Invoice: P98NOR03
Date: 31-Oct-98

Attention: Larry Mathews
Area: Heath Steele 2D

For services rendered during the month of October 1998, including:

Providing noise attenuation services for your Heath Steele 2D project.

LINE No.	# OF REC'S	TR/PER REC	\$ PER REC	TOTAL \$
2D	227	633	15.00	\$ 3,405.00
				\$ 3,405.00

Sub Total \$ 3,405.00

GST Reg. No. 139652044

GST @ 7% \$ 238.35

TOTAL \$ 3,643.35

OK LM
Charge to 118-252 Service

22

2720 - 5th Avenue N.E.
CALGARY, ALBERTA T2A 4V4
(403) 272-9754
FAX (403) 273-5293
G.S.T. # R102730967

J.R.S. EXPLORATION COMPANY LTD.

TO: NORANDA MINING AND EXPLORATION INC.
2800, 605 - 5th Avenue S.W.
Calgary, Alberta

DATE: October 7, 1998

INVOICE No.: 0298-10-4703

Attention: Mr. Larry Matthews

September 1998, Billing

DESCRIPTION	AMOUNT
PARTY NO. 779, HEATH STEELE 2D PROGRAM, NEW BRUNSWICK JOB NO. 98-006	
<u>As Per Proposal Dated September 20, 1998</u>	
F. <u>Hourly Recording</u>	
Period September 22 - 24, 1998	
28.0 Hours @ \$ 1,030.00 Per Hour	
G. <u>Additional Personnel and Equipment</u>	
g.) <u>Recording Helpers</u>	
Period September 22 - 23, 1998	
3 Helpers x 2 Days @ \$ 225.00 Per Day Each	
H. <u>Not Included In The Hourly Rate</u>	
<u>Subsistence for Helicopter Personnel</u> - As Per Hotshot Sheet	
Period September 22 - 24, 1998	
4 Mandays @ \$ 35.00 Per Manday	
TOTAL AMOUNT OF INVOICE	Continued - 2

COPY ONLY
PAID
OCT 14 '98
\$ 28,840.00 ✓
1,350.00 ✓
140.00 ✓

DESCRIPTION	AMOUNT
<u>Accommodation For Helicopter Personnel</u>	
Econo Inn Cash Receipt No. 203528 (Partial Receipt Only)	\$ 86.28 ✓
Econo Inn Cash Receipt No. 203527 (Partial Receipt Only)	86.28 ✓
Sub - Total of G.S.T. Items Only	<u>\$ 30,502.56</u>
G.S.T.	2,135.18
OK L-1 change to 191-065 license	
TOTAL AMOUNT OF INVOICE	<u>\$ 32,637.74</u>

24

